

# Cell Cycle & Cell division

\* All organisms start their life as a single cell.

\* Characteristics of cell (inherent of all living org)  
 → Growth  
 → Reproduction

## CELL CYCLE

During the division of cell

→ DNA replication  
 → Cell growth  
 place → takes

\* All the processes (cell division, DNA replication, Cell growth) have to take place in a co-ordinated way

① Sequence of events

by which cell duplicates its genome

synthesizes other constituents of the cell.

& eventually divides into 2 daughter cells

CELL CYCLE

Cell growth (in form of cytoplasmic increase) → continuous

DNA replication (synthesis) only one specific stage in cell cycle.

Replicated chromosomes (DNA) then distributed to daughter nuclei by a complex series of events

cell division during

\* These events are under Genetic control.

## Phases Of Cell cycle

\* Typical eukaryotic cell illustrated human culture cells

\* Duration of cell cycle vary from ① organism to organism

② cell type to cell type

≈ 24 hrs (every) ← these divide

\* YEAST cell cycle → 90 min

Cell cycle divided into 2 phases. (Basic)

### INTERPHASE

→ Resting phase

\* Phase b/w 2 successive M-phase

\* Lasts more than 95% of duration.

Cell is preparing for division by undergoing

① Cell growth

② DNA replication

in orderly manner.

cell division proper

### M Phase (Mitosis phase)

\* Actual division / Mitosis

\* about an hr (≈ 1 hr)

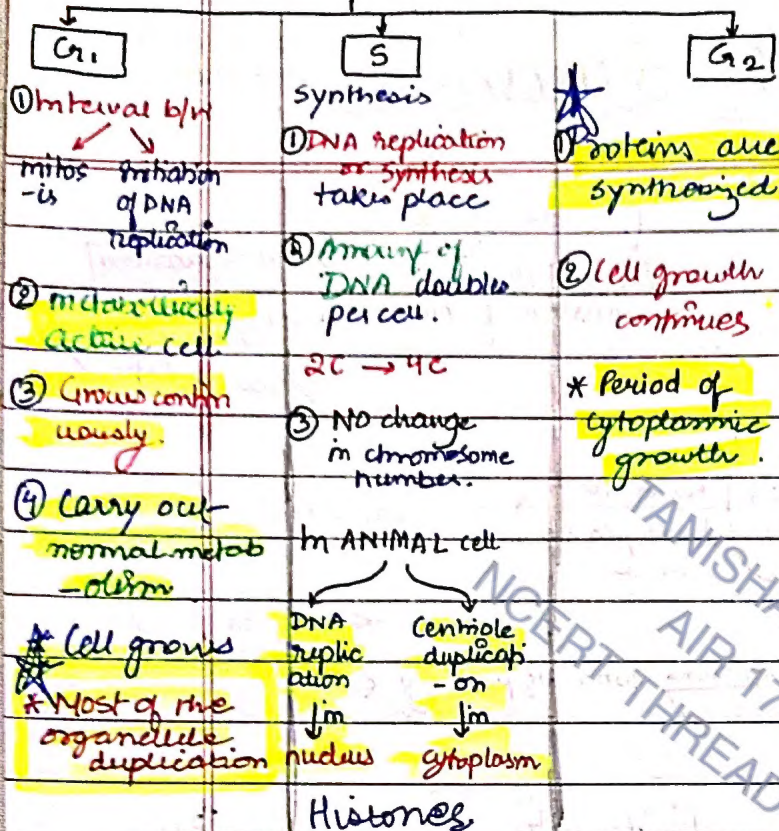
starts with → nuclear division

(KARYOKINESIS) separation of daughter chromosomes

usually ends with (CYTOKINESIS) division of cytoplasm



divided into



\* Most dramatic period of cell

\* Involves  $\rightarrow$  major reorganisation of virtually all the components of cell.

\* EQUATIONAL DIVISION  $\rightarrow$  no. of chromosomes remain same.

\* Cell division is progressive

b/w various stages cannot be drawn

Very clear cut division

④ phases: P M A T

**PROPHASE** 1st stage of mitosis.

\* Follows  $G_1$  &  $G_2$  phases

In S & G<sub>2</sub> phase new DNA molecules are ① Distinct ② Interspersed

Prophase is marked by initiation of condensation of chromosomal material.

chromosomal material becomes **untangled**

Chromatin Condensation during

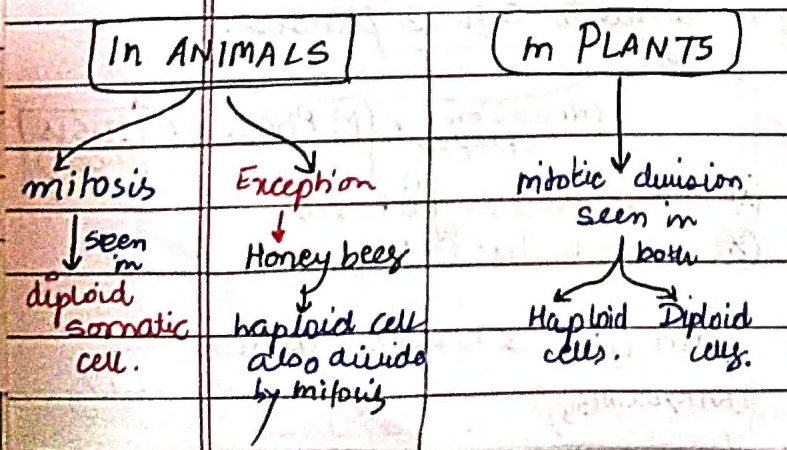
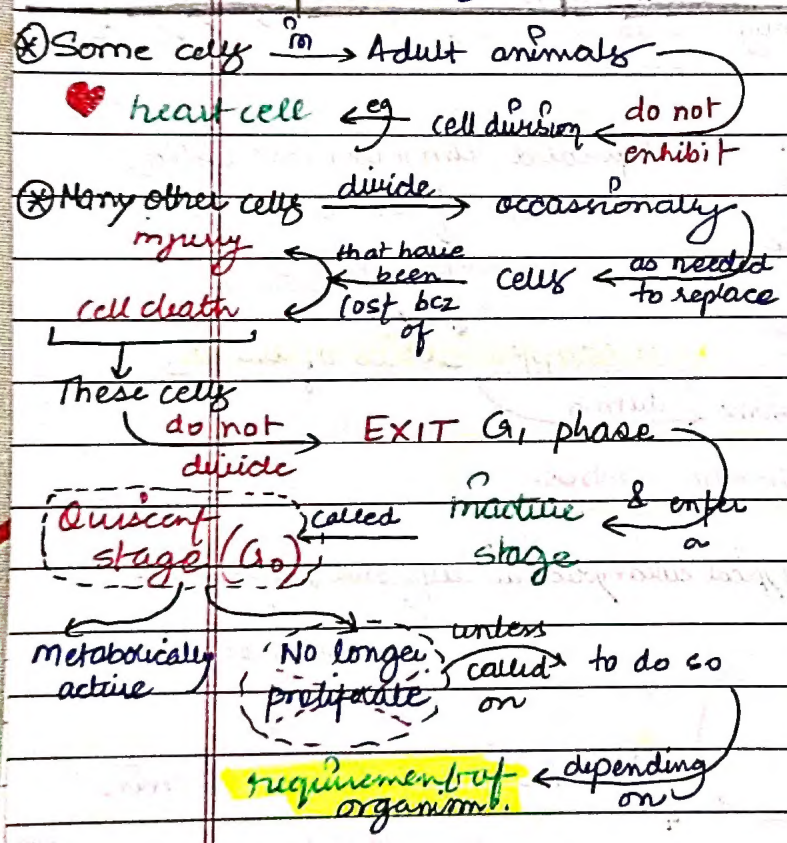
Duplicated centrosome begins to move towards opposite poles

\* Completion of prophase is marked by

Chromosome material	Chromosome	Each centrosome	viewed under microscope
condenses to form compact mitotic chromosome	seen as 2 chromatids attached at centromere	radiates out	do not form
		Microtubules (astereles)	③ ER ④ nucleolus ⑤ nuclear envelope

2 asters + spindle fibres  $\rightarrow$  mitotic apparatus

\* Spindle fibres start appearing





# METAPHASE

Complete disintegration

↓ of nuclear envelope

↓ marks start of this phase

Chromosomes are spread through cytoplasm

By this stage Condensation of chromosome is completed

microscope ← under clearly ← can be observed

\* At this stage MORPHOLOGY can clearly be studied



Metaphase chromosomes

made of 2 sister chromatids held together at centromere

\* Small disc shaped structures at the surface of Centromere are called Kinetochore

Chromosome to spindle fibres ← site of attachment ← these structures serve as  
that are moved → into position at the centre of cell

\* Metaphase is characterised by All chromosomes coming to lie at equator with one chromatid  
Spindle fibres from one pole to kinetochore connected by chromosomes of each  
→ its sister chromatid to other pole

\* The plane of alignment of chromosome at metaphase → metaphase plate

Key features of metaphase

# ANAPHASE

\* Onset of this phase → each chromosome split simultaneously

\* As each chromosome moves away → Centromere directed towards pole (hence at leading edge)

\* Anaphase characterised by

Centromere split  
↓  
chromatid separate

Chromatids move towards opposite poles

Spindle fibre attaching to kinetochore of chromosome

Chromosomes are moved to spindle equator  
↓ get aligned along metaphase plate  
spindle fibres to both poles

2 daughter chromatids (Referred to as daughter chromosomes of future daughter nuclei) begin migration towards

With arms of chromosome trailing behind 2 opposite poles



# TELOPHASE

\* At beginning of this stage

Chromosome have reached respective poles.

decondense  
individuality lost



Date

Individual chromosome

No longer be seen

## Key Events

Reformation of Golgi ER Nucleolus

Nuclear envelope dissolves

↓ around chromosome cluster

at each pole forming 2 daughter nuclei

Collect at each of 2 poles

→ fends to

each set of chromatin material

Chromosome cluster at opposite spindle poles

as their identity lost discrete elements

# Cytokinesis

Accomplishes

① karyokinesis

② cytokinesis at the end cell division completes.

## ANIMAL CELL

Appearance of furrow in the plasma membrane.

- ① Furrow deepens
- ② Ultimately joins in centre

During cytokinesis, organelles like Mitochondria, Plastids get distributed b/w 2 daughter cells

enclosed by relatively inextensible cell wall.

## PLANT CELL

Therefore undergo cytokinesis

Wall formation

existing lateral walls

to meet

starts in centre & grows outward

Precursor of new cell wall

→ Cell plate

→ middle lamella b/w the

Walls of 2 adjacent cells

\* In some organism, Karyokinesis followed cytokinesis results in formation of lig. endosperm in coconut. syngonium

# SIGNIFICANCE OF MITOSIS

\* Growth of multicellular organism due to mitosis

\* Mitosis - cell repair

upper layer of epidermis

cells lining the gut

Blood cells

(There can be no cell division without DNA replication)

\* Mitosis divisions in meristematic tissue

→ Pteridophyte, Chlamydomonas, Spirogyra

Some lower plants

social insects

haploid cells divide by mitosis

honey bee

Haploid cells in higher plants where cell div. doesn't occur - microspore, megaspore

→ apical cambium

results in continuous growth of plant throughout life

→ lateral cambium



Cell growth *disturbs* nucleocytoplasmic ratio.

To  
restore  
it

→ mitosis occurs



# MEIOSIS

Prod. by sexual Reprod.

includes fusion of 2 gametes

\* Complete haploid set of chromosomes ← each with

Gametes are formed by specialised diploid cell

specialised kind of cell division

reduces the chromosome no.

results in

prod. of haploid daughter cells.

\* Meiosis ensures → prod. of haploid phase in life cycle of sexually reproducing organisms

\* Fertilization re-creates → diploid phase.

\* We come across meiosis during gametogenesis

in plants & animals

## KEY FEATURES OF MEIOSIS

2 sequential cycle

nuclear division called Meiosis I  
cell division called Meiosis II

BUT single cycle of DNA replication

initiated after Parental chromosomes have replicated to produce identical sister chromatids

at S-phase.

\* Pairing of homologous chromosomes

4 haploid cells are formed at the end.

\* Recombination b/w non-sister chromatids of homologous chromosomes.

## MEIOSIS - I

① PROPHASE I: Typically longer & complex than mitotic prophase.

\* Long stage

Relatively short lived stages than

### LEPTOTENE

\* Chromosomes become gradually visible under a LIGHT MICROSCOPE. \*

\* Compaction of chromosome continues throughout this stage.

\* Complex formed by a pair of synapsed homologous chromosome called BIVALENT / TETRAD

More clearly visible in next stage pachytene.

### ZYGOTENE

\* Chromosome starts pairing. This process of association is called SYNAPSIS

\* Such paired chromosomes are called Homologous chromosome.

\* ELECTRON MICROGRAPHS of this stage indicate that synapsis is accompanied by formation of a complex structure called SYNAPTONEMAL COMPLEX.

### PACHYTENE

\* 4 chromatids of each bivalent chromosome become distinct & clearly appear as TETRAD.

\* This stage characterised by appearance of recombination nodules

↓ sites at which CROSSING OVER occurs b/w non sister chromatids of homologous chromosome

\* CROSSING OVER is exchange of genetic material b/w two homologous chromosomes.

\* CROSSING OVER is enzyme mediated process

\* Enzyme involved RECOMBINASE

\* Crossing over leads to recombination of genetic material on the 2 chromosomes.

\* Recombination completed at end of this stage.

↓ leaving chromosome linked at the site of crossing over.

### DIPLTENE

\* Recognized by dissolution of synaptonemal complex.

\* Tendency of recombined homologous chromosomes to separate except at the site of cross over.

\* X shaped structures are called CHIASMATA

\* In oocyte of some vertebrates diplotene can last for MONTHS or YEARS



## FINAL STAGE — DIAKINESIS

DIAKINESIS represents transition to METAPHASE.

\* Marked by — Terminalisation of chiasmata

\* Chromosomes — fully condensed.

\* Meiotic spindle — assembled to prepare homologous chromosomes for separation

\* By the end of this stage — Nucleolus disappears  
Nuclear envelope breakdown.

MEIOTIC SPINDLE

## METAPHASE - I

\* Bivalent chromosomes — align on equatorial plate

\* Microtubules from opposite poles attach to kinetochore of homologous chromosome.

## ANAPHASE - I

→ HOMOLOGOUS CHROMOSOMES separate.

→ SISTER CHROMATIDS — remain associated at their centromeres.

## TELOPHASE - I

• Nucleolus  
• Nuclear membrane } reappear. → CYTOKINESIS followed

\* ALTHOUGH IN MANY CASES

DYAD OF CELLS. ← resulting in

Chromosomes do undergo some dispersion

interphase nucleus ← of extremely extended state ← they do not reach

\* THE STAGE b/w 2 meiotic divisions — is called INTERKINESIS (generally short lived)

\* NO DNA REPLICATION IN INTERKINESIS

\* INTERKINESIS is followed by prophase - II (much simpler than prophase - I)

## MEIOSIS - II

→ initiated immediately after cytokinesis usually before chromosomes have fully elongated

→ Resembles — NORMAL MITOSIS

### Prophase - II

• Nuclear membrane disappears by the end of this stage.

• Chromosomes again become compact.

### METAPHASE - II

\* Chromosomes align at the equator.

\* Microtubules from opposite poles of the spindle get attached to kinetochores of sister chromatids.

### ANAPHASE - II

\* Begins with — simultaneous splitting of the centromere of each chromosome.

\* Move towards opposite poles by shortening of microtubules attached to kinetochores.

### TELOPHASE - II

\* 2 groups of chromosome get enclosed by nuclear envelope.

\* Followed by CYTOKINESIS resulting in TETRAD OF CELLS (4 haploid daughter cells)

## SIGNIFICANCE OF MEIOSIS

\* Conservation of specific chromosome no. of each species achieved across generations in sexually reproducing organisms.

\* Even though process, per se, paradoxically results in reduction in chromosome no. by half.

\* It increases genetic variability in population of organism from one generation to the next.

\* VARIATIONS very important — for process of EVOLUTION.